

# Managing declining pine stands for red-cockaded woodpecker habitat at Fort Benning, GA and Camp Lejeune, NC (RC-1474)

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Department of Defense land managers require guidelines for restoring longleaf pine (LLP; *Pinus palustris*) to existing loblolly pine (LBP; *Pinus taeda*) forests to provide habitat for the federally endangered red-cockaded woodpecker (RCW; *Picoides borealis*) and to meet other management objectives. Reports of declining health in existing LBP stands increase the urgency for developing such protocols.

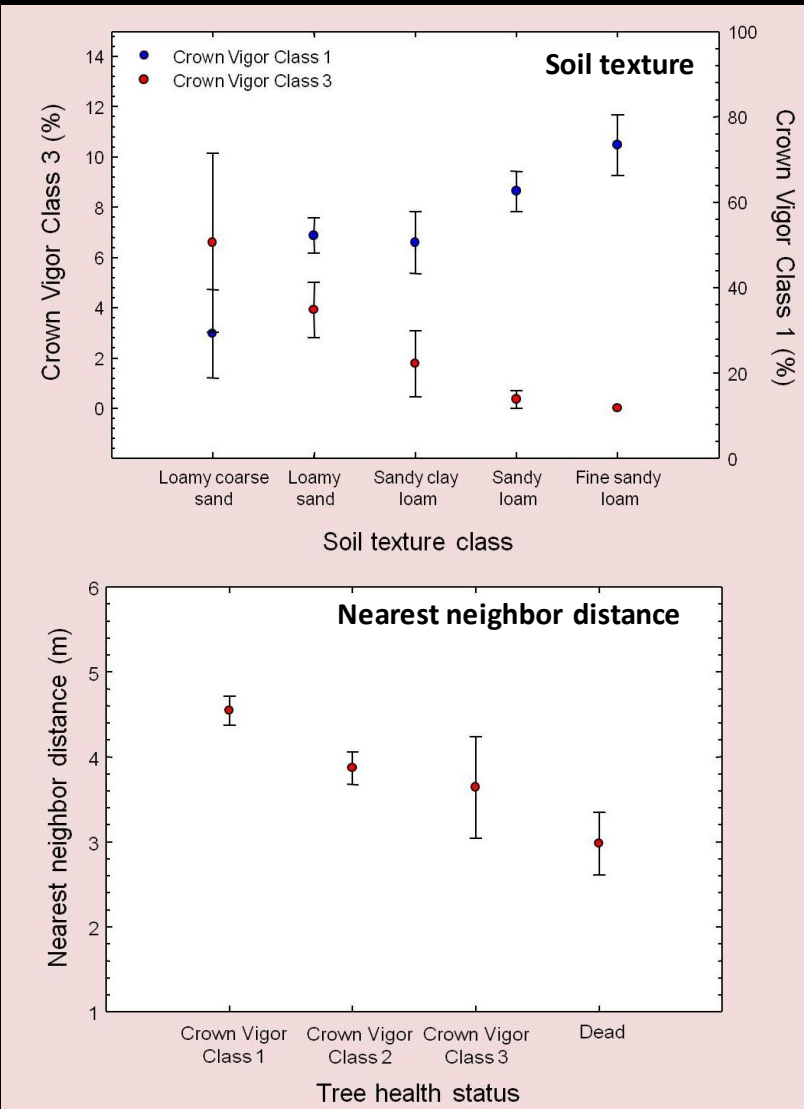
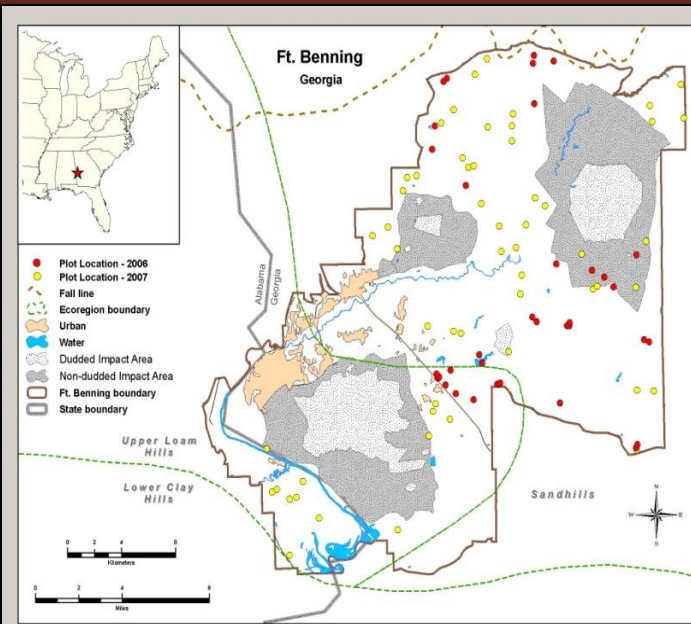
We addressed this problem using two approaches:

- 1) A **field survey** was used to describe and predict loblolly pine stand health at Fort Benning Military Reservation
- 2) A **replicated field experiment** was used to determine effects of varying canopy density and distribution on longleaf pine ecosystem restoration at Fort Benning Military Reservation and Marine Corps Base Camp Lejeune

## Loblolly pine stand health

Reports of poor loblolly pine health in upland forests at Fort Benning, GA raise questions as to the longevity of existing RCW habitat. Managers require information describing stand health and factors related to potential decline. Stands vulnerable to decline can be targeted for conversion to LLP to meet long-term RCW management objectives.

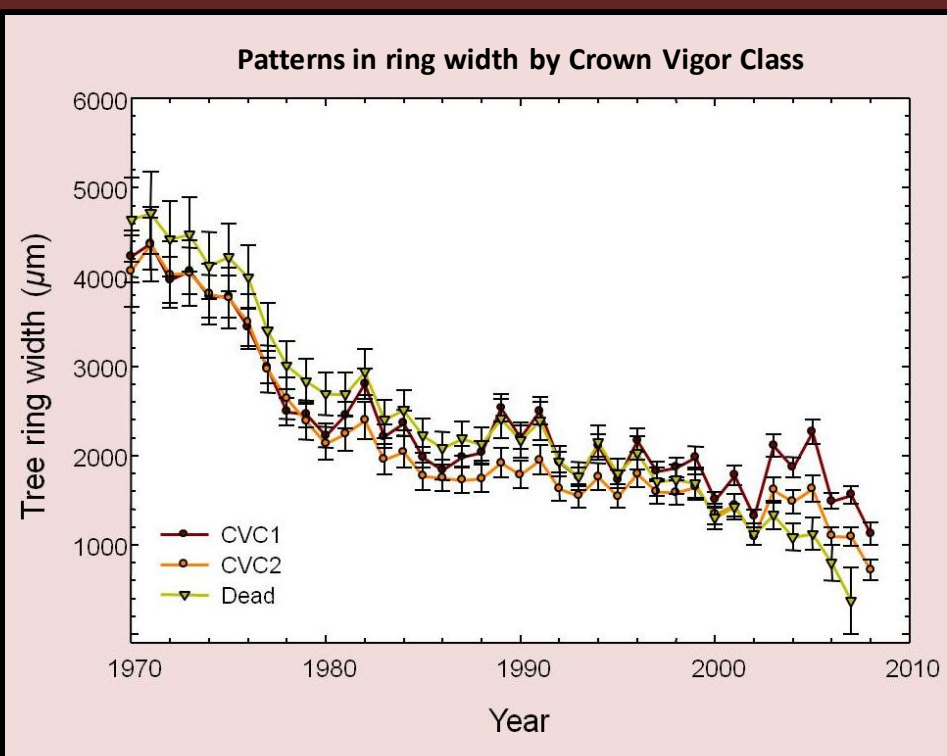
We established 89 monitoring plots across a range of site and stand conditions at Fort Benning to characterize loblolly pine stand health.



We used USDA Forest Service Forest Health Monitoring protocol to describe individual tree health by categorizing trees into Crown Vigor Classes (1 = healthy; 2 = intermediate; 3 = unhealthy; DC = dead). Overall, the majority of canopy pines were classified as healthy (54.1%), with only 2.9% classified as unhealthy and 8.2% dead.

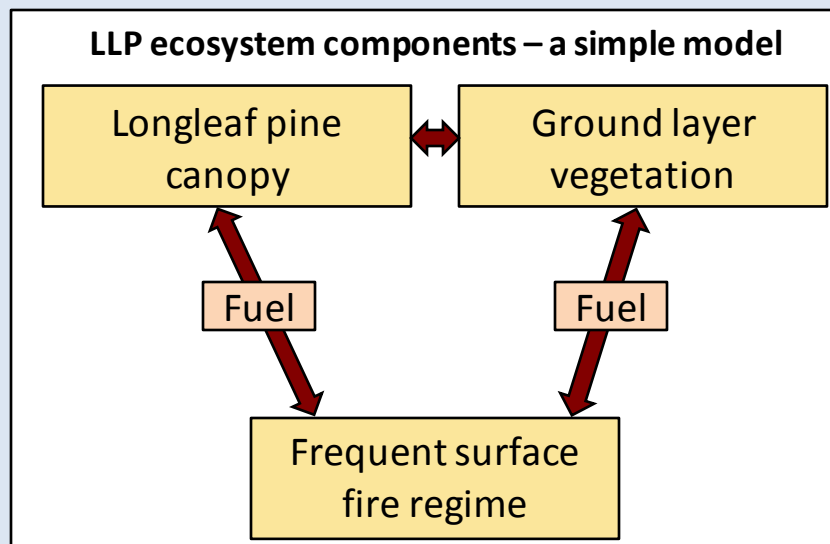
We found that **soil texture** was related to tree health, with the incidence of poor health increasing with soil sand content. In addition, the spatial distribution of canopy pines suggested that density-dependent relationships were affecting pine health. Average **nearest neighbor distance** was higher for healthy trees than for dead or unhealthy trees. We found that dead trees had significantly higher competition from surrounding trees within an 8 m radius area when compared to healthy trees. Our results suggest that the observations of poor health may be related to harsh conditions of sandy sites and natural thinning in locally dense patches.

We used **dendrochronology** to explore patterns in individual tree mortality. Within ten years prior to analysis, growth patterns diverged among healthy, unhealthy, and dead trees. Logistic regression was used to predict tree mortality based on growth level variables, growth trend variables, and relative basal area increment over 3 years and relative basal area growth created the best predictive model, with 75.0% success at classifying dead trees and 73.4% success at classifying live trees. These results demonstrate that tree mortality may be anticipated through analysis of tree ring patterns prior to mortality events.



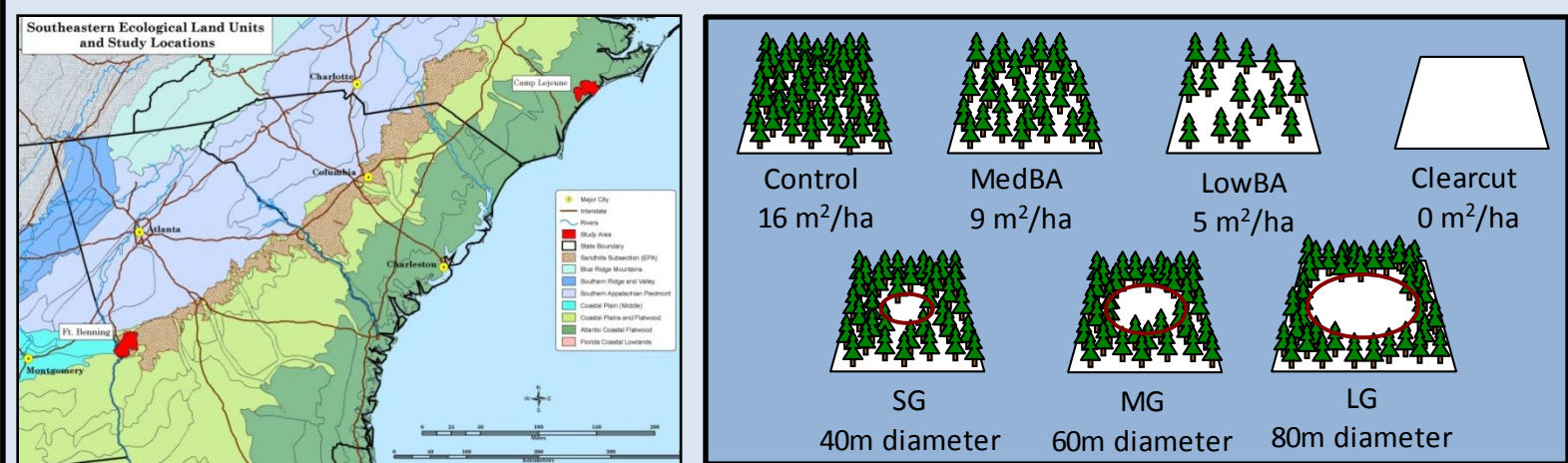
## Longleaf pine ecosystem restoration

Longleaf pine ecosystem restoration requires attention to the **structure**, **composition**, and **function** of the LLP forest. Frequent, low-intensity surface fires are critical to maintaining desired ecological components. The mixture of herbaceous ground layer vegetation and needle fall from canopy pines provides important fuels to support the frequent fire regime. Conversion of existing pine stands to LLP must balance canopy retention with removal



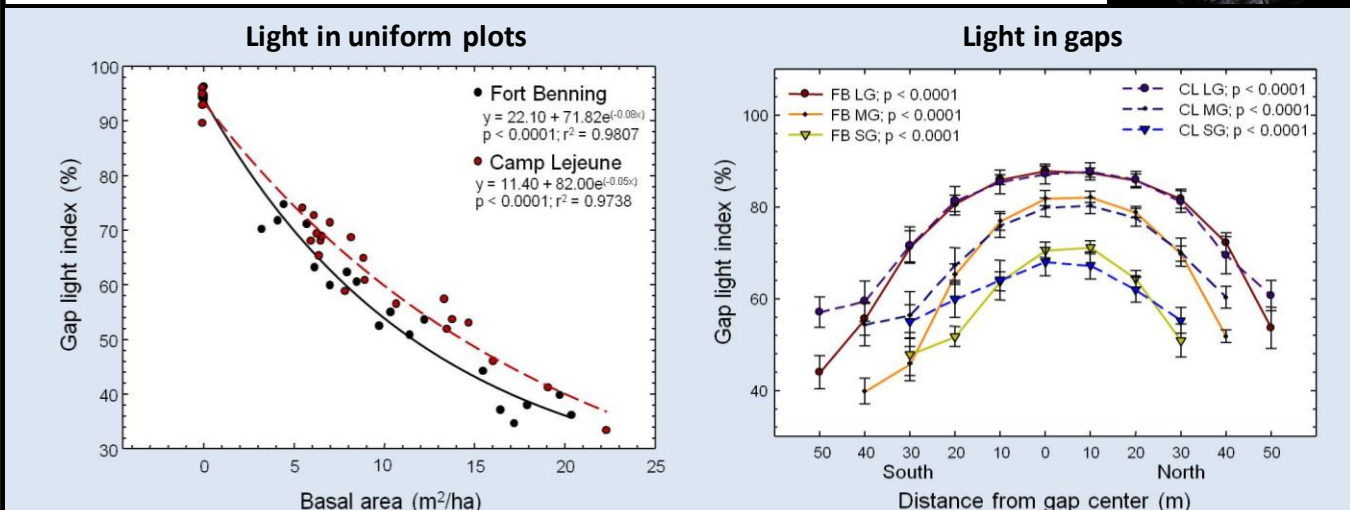
to optimize restoration at the ecosystem level.

We established a randomized, complete block, split-plot experiment to test effects of seven canopy treatments on planted longleaf pine seedling response and ecosystem development. Split-plot treatments included herbicide and fertilizer treatments used in conjunction with longleaf pine establishment. The study was replicated with six blocks at Fort Benning, GA and seven blocks at Camp Lejeune, NC.

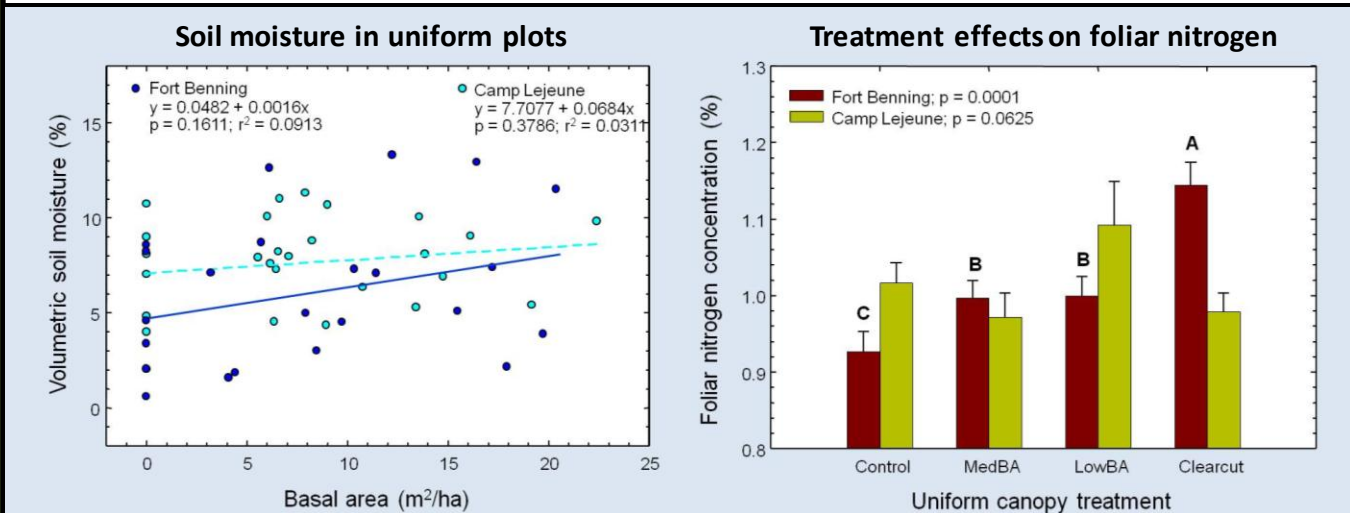


## Resource availability

We measured resource availability relative to canopy density treatments and distance from forest edge in gap treatments. **Light** availability increased with canopy removal and distance from forest edge, although light levels were highest on the northern half compared to the southern half of gaps, regardless of gap size.

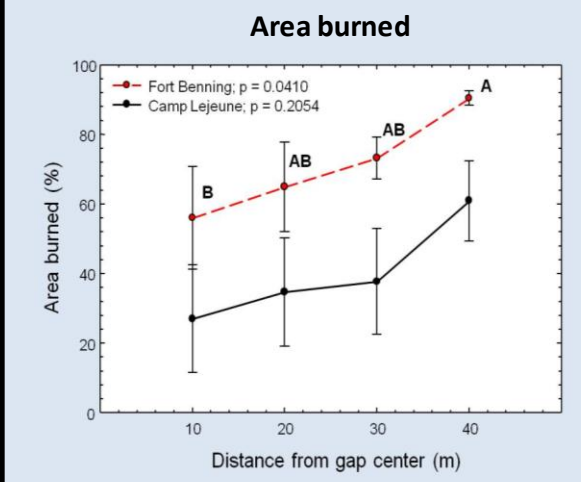
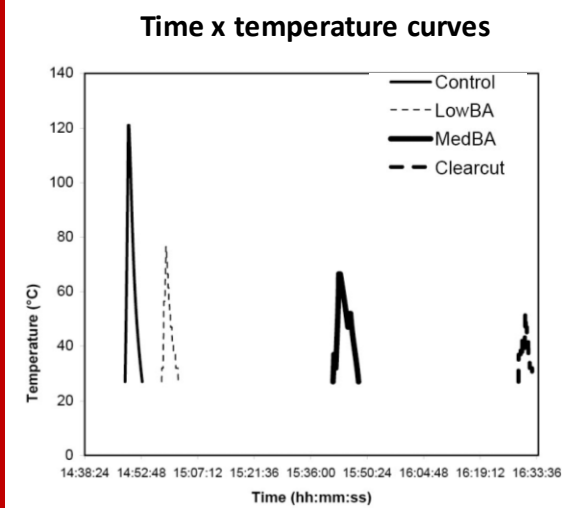
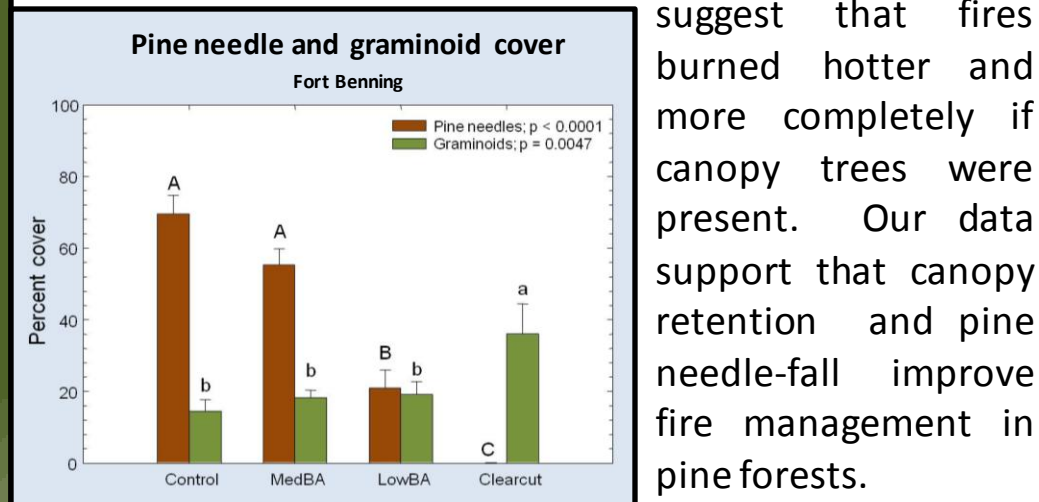


**Soil moisture** was not affected by canopy density or canopy gap position at either study site. **Foliar nutrient** concentrations of three year-old longleaf pine seedlings were generally higher on treatments that removed canopy pines, but differences between study sites demonstrate that multiple controls affect ecological patterns. For example, foliar nitrogen concentrations were highest on Clearcut plots at Fort Benning, but no differences were observed in foliar nitrogen at Camp Lejeune.



## Fuels and fire response

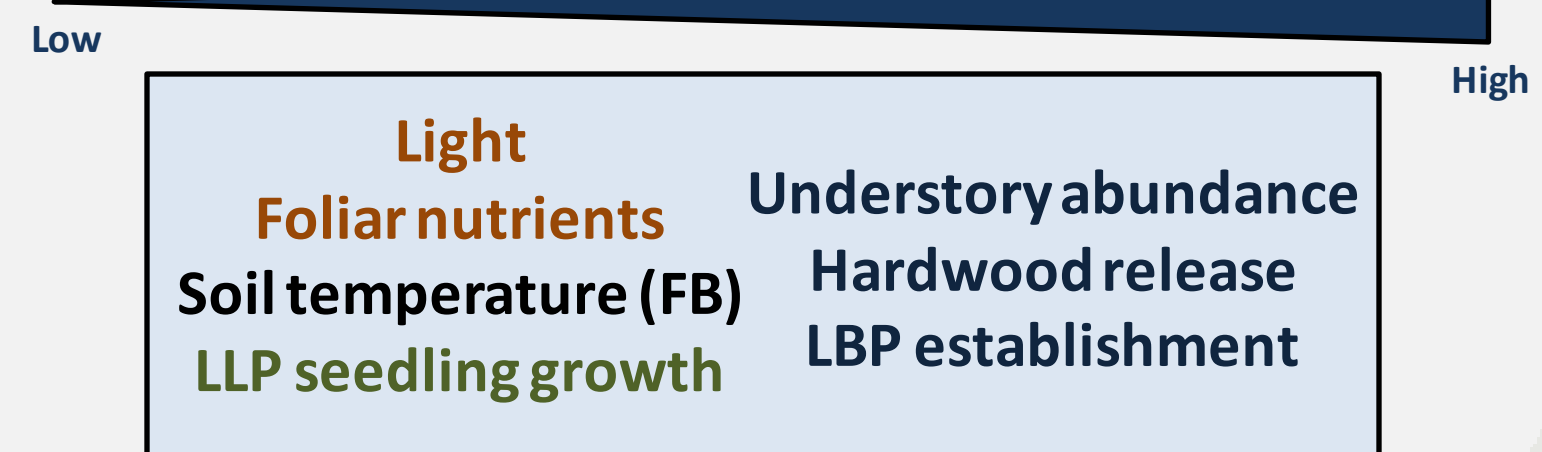
We measured fuels before and after applying prescribed fire two growing seasons after canopy harvest. **Pine needles** and **graminoids** represent two important fine fuels in pine forests but displayed different trends with canopy removal. Measures of fire behavior, including **temperature curves** generated by thermocouple data-loggers and measures of **percent area burned**, both



Intact canopy  
Forest edge

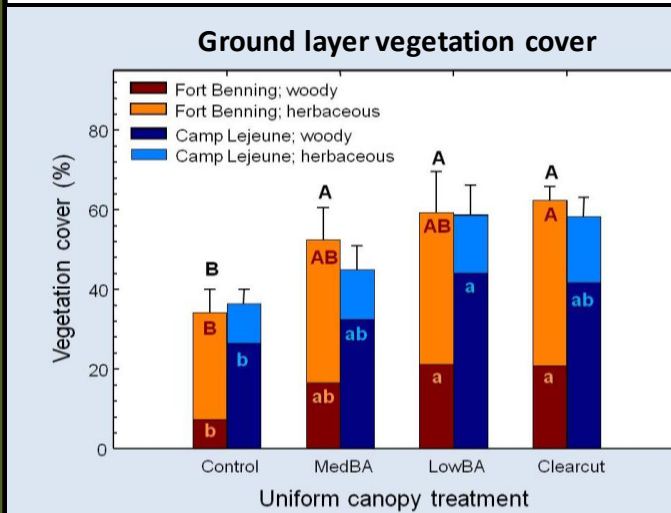
Uniform  
Gaps

Clear-cut  
Gap center



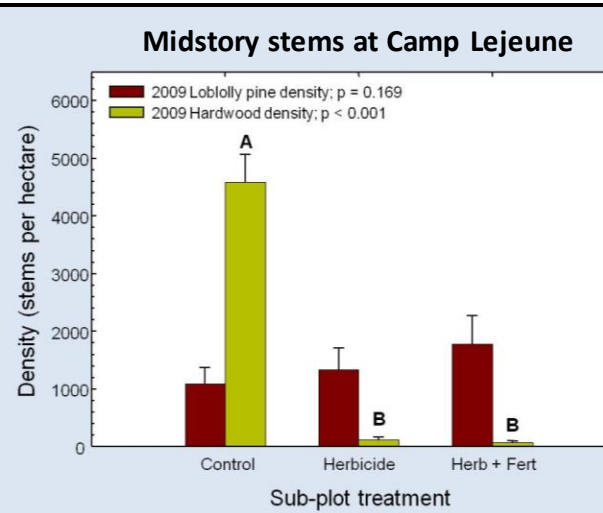
## Patterns of response to canopy density and gap position

Cover of **ground layer vegetation** increased with decreasing basal area. At Fort Benning herbaceous vegetation dominated, but at Camp Lejeune woody vegetation was more abundant. As a result, the **density of woody stems** in the midstory layer was high at Camp Lejeune. Herbicide treatments

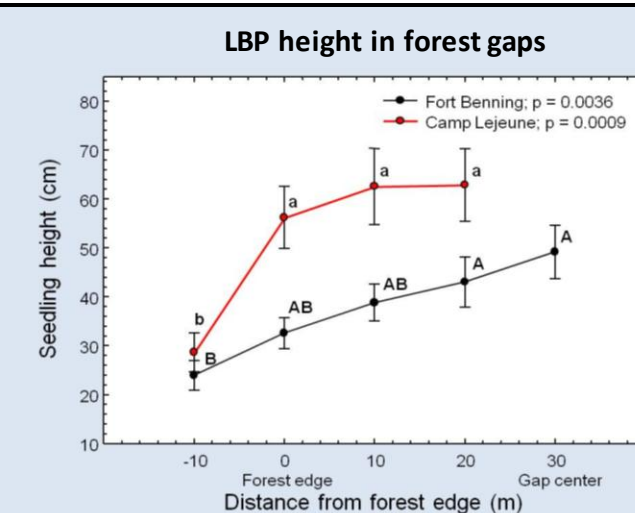


## Vegetation

significantly reduced density of woody stems but had no effect on the density of LBP regeneration. Although LBP density was positively

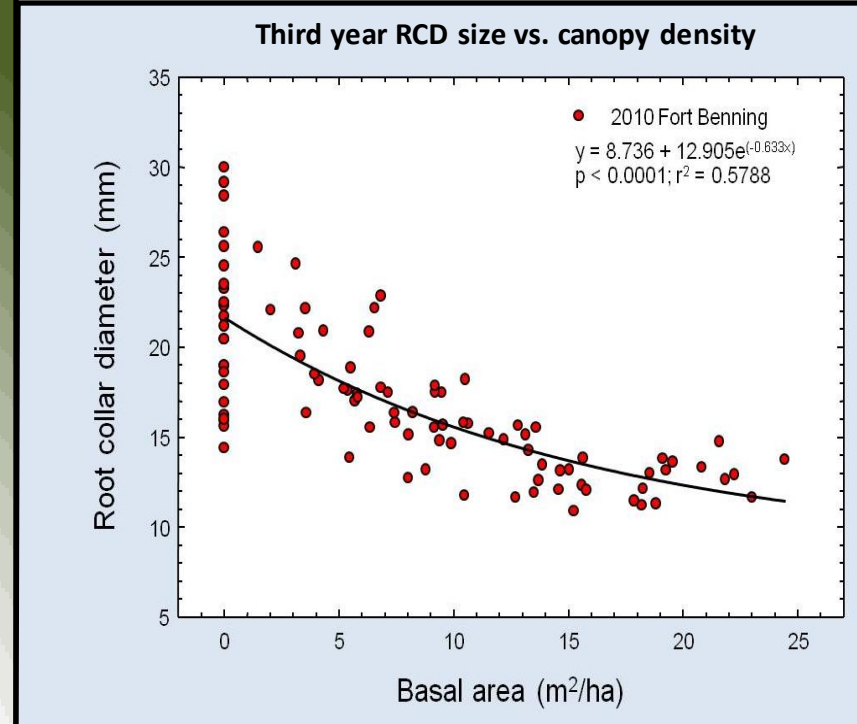


correlated with LBP canopy density, **growth of LBP regeneration** increased with canopy reduction and distance from the forest edge. At Camp Lejeune, the abundance of LBP regeneration threatens LLP restoration success and demonstrates the importance of fire management for LBP control.

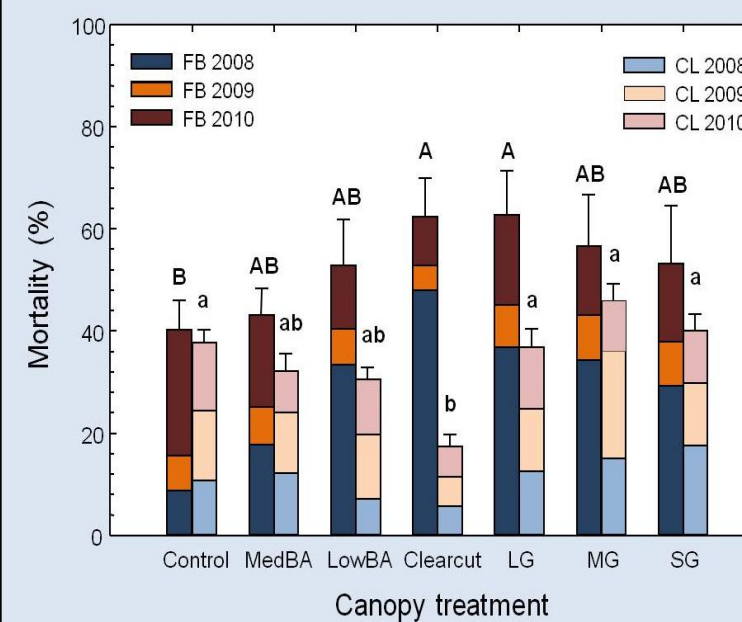


## LLP seedlings

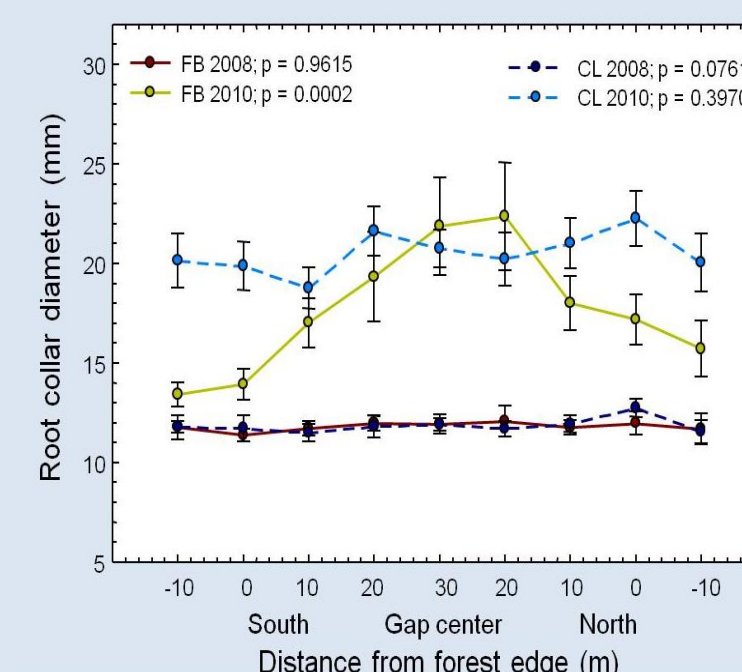
Longleaf pine seedlings were planted in 2008, and survival and growth were monitored in response to our study treatments. **Mortality** was highest in Clear-cut plots and lowest in uncut plots at Fort Benning, but the opposite pattern was observed at Camp Lejeune. **Seedling growth** (root collar diameter; RCD) increased with distance from the forest edge in gaps at Fort Benning but not at Camp Lejeune. Our results suggest that canopy retention may improve seedling survival but will reduce growth under certain conditions.



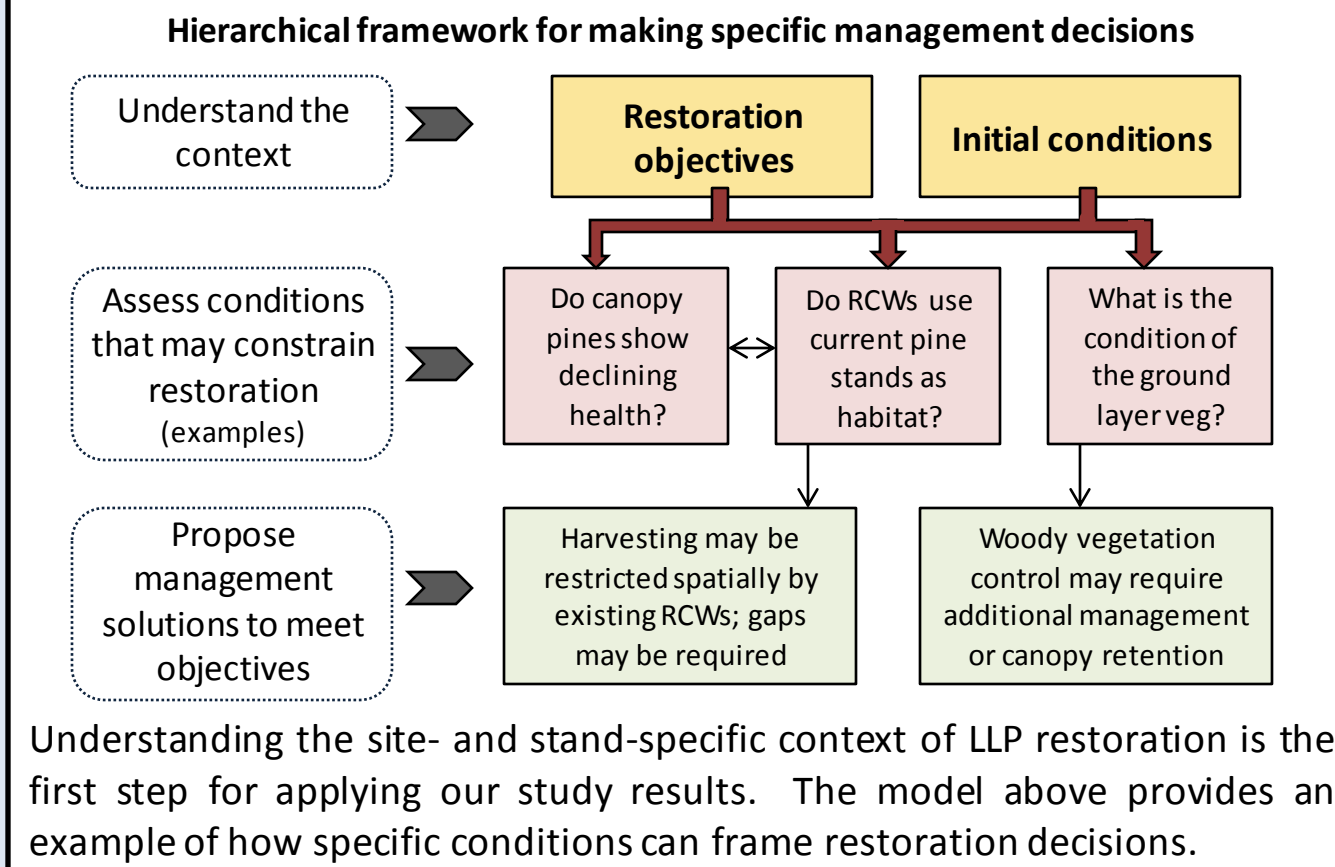
## LLP mortality by canopy treatment



## Seedling RCD relative to gap position



## Developing management guidelines



Generally, our results support that levels of canopy retention between 5 and 8 m²/ha will successfully balance components of LLP ecosystem restoration, including longleaf pine seedling establishment and growth, pine needle inputs, ground layer vegetation development, fire management, and maintenance of RCW habitat. Canopy gaps present a flexible alternative to single-tree selection, and we recommend the use of small gaps (0.1 ha) to maintain important ecological processes. Differences in response between Fort Benning and Camp Lejeune demonstrate that restoration decisions must consider regional and site-specific conditions for effective application.

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